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THEORETICAL REVIEW

The effect of the work environment on future sleep disturbances: a systematic review

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SUMMARY

Workers often attribute poor sleep to factors at work. Despite the large number of workers with sleep disturbances, there is a lack of consensus on the relationship between the work environment and sleep. The purpose of this systematic review therefore was to conduct a comprehensive evaluation. To this end, we employed standardized methods to systematically locate, review, and tabulate the results of prospective or randomized studies of the impact of work factors on sleep disturbances. From the 7981 articles located in five databases, 24 fulfilled our inclusion criteria and formed the base of the review including meta-analyses of the effect sizes. Results showed that the psychosocial work variables of social support at work, control, and organizational justice were related to fewer sleep disturbances, while high work demands, job strain, bullying, and effort-reward imbalance were related to more future sleep disturbances. Moreover, working a steady shift was associated with disturbances while exiting shift work was associated with less disturbed sleep. We conclude that psychosocial work factors and the scheduling of work have an impact on sleep disturbances and this might be utilized in the clinic as well as for planning work environments. Future research needs to employ better methodology and focus on underlying mechanisms.

Introduction

Sleep disturbances are a primary health concern for workers in industrialized countries. Epidemiological surveys reveal that about one-third of the general adult population report difficulties sleeping and about 6–10% fulfill the DSM-IV (Diagnostic and Statistical Manual) criteria for insomnia [1–3]. In the US for example, 9.3% of the population suffer from chronic insomnia with a higher prevalence for women (12.9%) than for men (6.2%) [2]. Disturbed sleep, as used in this paper, includes the core symptoms of insomnia, including difficulty initiating or maintaining sleep, waking up too early, non-restorative sleep and overall dissatisfaction with sleep [4]. Recent evidence suggests that the prevalence of insomnia has increased over the last decade, and is now the second most frequent health complaint after pain, affecting almost everybody at some point in life [5–7]. Moreover, insomnia has grave consequences as it is associated with a host of symptoms e.g., decreased function, increased fatigue, and decreased well-being and it may also be associated with a range of health problems including heart disease, mental health, and diabetes [1,3].

Sufferers often attribute their sleeping problem to factors in the work environment. These factors include stress, organizational factors, work schedules, psychosocial factors and exposure to various physical factors like chemicals or physical loading. In Sweden every fifth worker reports that work has affected their ability to sleep [8] and work stress is the most frequent self-reported cause of sleeping difficulties [9].

Indeed, work stress is an important risk factor for poor sleep [10]. Psychosocial work factors resulting in stress have been implicated in the development of sleep problems and the implicit

Abbreviations: CI, confidence interval; DSM, Diagnostic and Statistical Manual of Mental Disorders; exp, exposed; f, females; ICD, International Classification of Diseases; m, males; ns, not significant; OR, odds ratio; SBU, Swedish Council for Health Technology Assessment; REM, rapid eye movement.

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assumption is that adverse psychosocial work factors are related to poor sleep [11]. Similarly, the corollary is that favorable psychosocial work factors should be linked to good sleep. Variables such as work demands, pace, level of control, social support, organizational justice, workload, job strain, and job security are conceptualized as psychosocial work factors [12,13]. Models have been developed that tap into how the work environment exerts stress on employees. The demand-control theory [14] proposes that an imbalance between the demands placed on the worker and that person's decision latitude or control results in stress, especially so-called job strain (i.e., high demands, low control). An overlapping conceptualization is the effort-reward model where an imbalance between the effort to do the job and the reward it provides is said to create stress [15,16]. More recent concepts like organizational justice and job security have also been introduced to describe the work environment [17].

A second notion is that work schedules, such as working shifts, or nights influence sleep. Because sleep is closely tied to circadian rhythms, disruptions (night work) and the changing of work times disrupt sleeping patterns and may cause disturbed sleep. The idea that work schedules impact on sleep is not new [18,19]. However, today when only about one fourth of the work force have a regular daytime work schedule [20] the possible effects of work scheduling on sleep is pervasive.

A third area of interest for sleep is the physical work environment. Workers may be exposed to an array of working conditions including bacterial agents, chemicals, vibrations, noise, or heavy work. Any one of these might influence sleep e.g., by impacting on the nervous system.

Despite the prevalence of sleep complaints among workers and the implication of the work environment bearing on sleep, there is no current consensus on the relationship between the work environment and sleep. While some reviews have focused on specific work environment factors, populations, or sleep outcomes [11,18,20,21], there is a need for a comprehensive review that provides the “big picture” of our current knowledge. Moreover, while a good deal of research has focused on the effects of sleep deficits on work, examining the opposite direction of impact, i.e., the effects of work on sleep, is warranted given the large changes in working conditions that have occurred over the past 25 y.

Methodological challenges have however plagued and compromised the investigation of the effects of the work environment on sleep. First, a host of studies have employed cross-sectional designs. However, cross-sectional studies do not provide information about the temporal relationship between cause and effect and are thus prone to “reverse causation”, i.e., the possibility that a sleep disturbance affects the experience of the work environment. In prospective studies, data on study subjects are assessed over a period of time. This allows establishment of the temporal sequence of events and thus facilitates the interpretation of cause and effect. Additional methodological issues include accurate measurement of both the exposure and outcome variables, control for confounders, timeframes that capture the latency of the work place variables, and appropriate statistical analyses. In this review, we have therefore chosen to focus on prospective studies, most with a follow up of at least 12 mo, case–control and intervention studies. Furthermore, in light of the methodological concerns, we have employed a systematic method for judging the relevance and scientific standard of each study to ensure that all of the studies provide worthwhile information based on strong designs.

The aim of this paper then, is to review systematically the literature on the effects of work on sleep. It is a comprehensive review that includes investigations of physical, organizational, and psychosocial factors at work that may impact on sleep using a longitudinal design. In addition to using systematic methods to locate the literature, we also employed standardized procedures for judging the relevance and quality of each study.

Methods

This systematic review was conducted and funded within the framework of the Swedish Council on Health Technology Assessment (SBU), a public agency (www.sbu.se) with the charge of providing impartial and scientifically reliable information to decision makers health care providers. The review was conducted according to the guidelines stated by PRISMA (i.e., the Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [22]. A systematic literature search for all available research on the topic was performed by an information specialist in five computerized data bases (PubMed, Embase, PsycInfo, Cochrane library, NIOSHTIC-2) with October 2012 as the latest search date. We focused on a broad range of known work environment variables (physical load, organizational and psychosocial factors, chemical and biological factors, noise, vibrations, contagious substances and other factors) and any measure of sleep disturbance including all ICD-10 sleep diagnoses and a combination of controlled search words (e.g., MeSH) and free-text words. Although objective measures are commonly preferred in clinical treatment settings, we also choose to include subjective measures since they encompass many different types of sleep problems and are commonly employed by researchers in this field. The search strategy for PubMed is available at www.sbu.se/work_sleep; we used a similar strategy for the other data bases.

Inclusion criteria were a prospective or randomized design; occupational focus; sleep disturbances not directly related to another illness such as depression; age and sex of participants reported; at least 30 people in the exposure group; and published between 1990 and 2012 in English, Swedish, Norwegian or Danish (although all articles included in the final review were published in English).

All steps of the selection process (Fig. 1 and Table 1) were based on detailed and predetermined appraisal forms (available on request). Abstract screening and full-text assessment for inclusion criteria were conducted by two people, a specialist in occupational medicine and a psychiatrist and an article was included if one assessed it as fulfilling the inclusion criteria. Assessment of relevance and quality was made by experts (e.g., in sleep medicine, psychiatry, psychology, occupational medicine, and epidemiologic methods), working in pairs. Before the assessments began, experts were trained to criteria by practicing and discussing ratings made using the forms until a satisfactorily high inter-rater reliability was achieved. Especially, we emphasized detecting potential bias in the methodology. The selection process resulted in 24 relevant studies fulfilling the inclusion and quality criteria. A detailed table showing the full results of the data extraction is available at www.sbu.se/work_sleep.

The included studies were tabulated and stratified according to occupational risk factor (Table 2) after the quality assessment process. Extracting data into the tables was done by two experts and subsequently scrutinized by the authors. Conclusions concerning relationships between work factors and sleep were made using all relevant data from all of the included studies. To assist in illustrating the results, and as a contribution to the overall assessment, meta-analyses were conducted when at least two studies analyzed the same risk factor and provided mathematically comparable data using the Comprehensive Meta Analysis software package (www.meta-analysis.com/index.php). Since the participants in the various studies might be construed as coming from the same population (workers) or from different populations (i.e.,

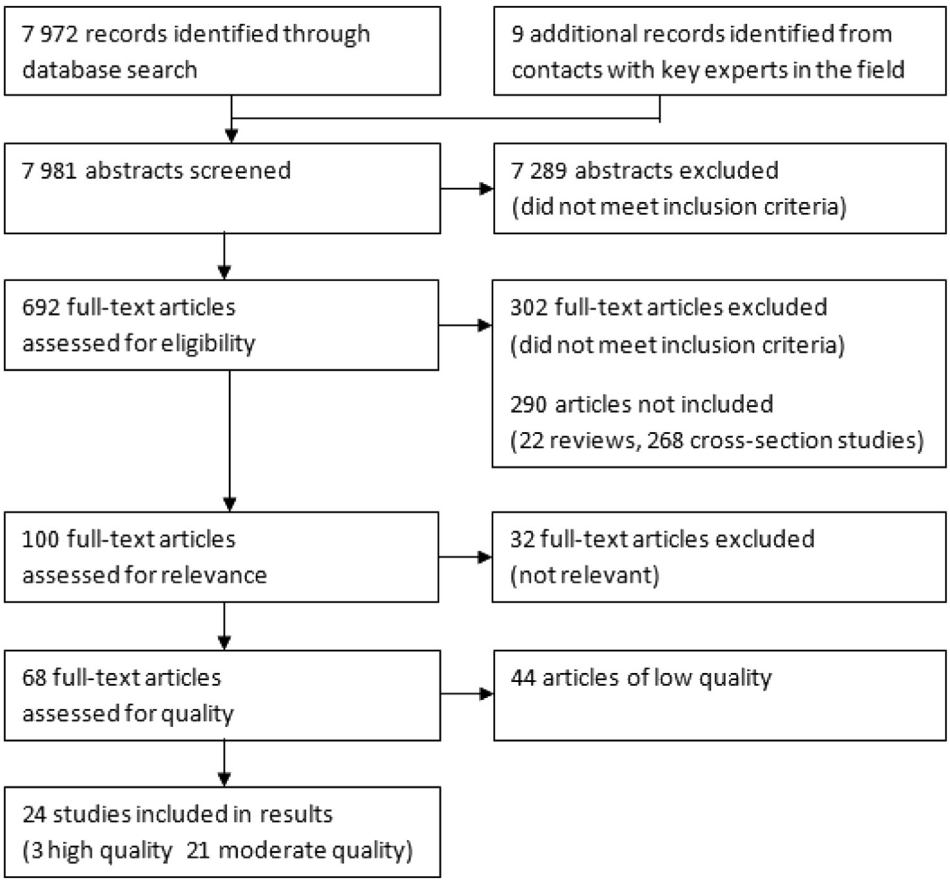

Fig. 1. The number of articles in the seven categories of work environment variables.

according to each study's inclusion criteria) we report the results for both a fixed and a random effects model. The strength of the scientific evidence, using data from all of the included studies (not just those illustrated in the meta-analyses), was determined by pairs of the authors of this paper and then discussed and confirmed by all authors using the four category GRADE system [23]. A brief description of the categories used in this review is presented in Table 3.

Results

As shown in Table 1, the number of articles identified in the review process was not evenly distributed among the major potential risk factors. The literature search identified most abstracts for physical exertion and psychosocial factors. However, after reviewing for inclusion criteria, relevance and quality, there were 22 studies concerning exposure to psychosocial factors at work but only two concerning chemical and biological factors that remained for further analysis.

The majority of the studies that fulfilled our inclusion, relevance, and quality criteria applied a prospective cohort design with at least one year follow-up time (>5 y: eight studies, 1–4 y: eight studies and<1 y: four studies). Since we focused on a working population, the age of the subjects was generally in the range of 18–60 y with a mean age in the late thirties to early forties. All but two studies had both male and female participants; on average each study involved one-third female participants (one third of the studies had a gender balance, i.e., 40–60% of each gender).

Psychosocial factors

The 22 studies included in this exposure category examined a range of variables often using existing models (e.g., demand-control) as a guide.

Table 1
The number of articles identified in the different steps of the selection process stratified by occupational exposure.

	Physical exertion	Psychosocial factors	Chemical and biological factors	Noise	Vibration	Radiation and temperature	Contagious substances
Records identified through database search and from contacts with key experts in the field	850	6324	133	261	285	117	11
Full-text articles fulfilling the inclusion criteria	4	362	13	6	1	4	0
Not included in the result; Cross-section studies	2	249	8	6		3	
Not included in the result; Reviews		22					
Not included in the result; Not relevant	1	30				1	
Not included in the result; Low quality	1	39	3		1		
Articles constituting the result; Moderate quality		19	2				
Articles constituting the result; High quality		3					

Table 2
Relationship between occupational exposure and sleep disturbances (exposure range, least adjusted model) for the included studies.

Author, reference number	Exposure	Outcome	Association
Demands			
Åkerstedt et al., 2012 [24]	Work demands	Disturbed sleep	High to consistently high demands, OR (95% CI) 1.48 (1.19; 1.83) to 1.87 (1.43; 2.44)
de Lange et al., 2009 [25]	Job demands	Sleep quality	Depending on time of measurement, correlation 0.12 to 0.15, both $p < 0.05$
Edmé et al., 2011 [26]	High demands	Sleep problems	OR (95% CI) f: 1.08 (0.58; 2.04), m: 2.20 (1.44; 3.35)
Eriksen et al., 2008 [27]	Quantitative work demands	Poor sleep	Level of demands (level 2–5), OR (95% CI) 1.35 (1.00; 1.81) to 1.54 (1.10; 2.17)
Hanson et al., 2011 [28]	Demands	Two outcomes, see column to the right	Standardized regression coefficient **Sleep disturbance**: 0.02, ns **Awakening problems**: 0.03, ns
Jansson and Linton, 2006 [29]	Work demands	Insomnia	Depending on insomnia at baseline OR (95% CI) no: 1.27 (1.02; 1.58), yes: 1.38 (1.11; 1.71)
Control			
Åkerstedt et al., 2012 [24]	Control	Disturbed sleep	Low to decreased control, OR (95% CI) 1.10 (0.89; 1.35) to 1.29 (0.92; 1.81)
Burgard and Ailshire, 2009 [31]	Low control	Sleep quality	Low to decreased control, OR (95% CI) 1.01 (0.935; 1.094) to 1.05 (0.969; 1.133)
de Lange et al., 2009 [25]	Job control	Sleep quality	Depending on time of measurement, correlation −0.06, $p < 0.05$, to −0.11, $p < 0.05$
Edmé et al., 2011 [26]	Low decision latitude	Sleep problems	OR (95% CI) f: 0.88 (0.44; 1.75), m: 1.18 (0.77; 1.80)
Eriksen et al., 2008 [27]	Control of work pace and decisions	Poor sleep	Work pace, level of control (level 5 to 2), OR (95% CI) 0.81 (0.57; 1.17) to 1.00 (0.76; 1.32) Work decisions, level of control (level 5 to 2), OR (95% CI) 0.95 (0.68; 1.31) to 1.11 (0.84; 1.46))
Hanson et al., 2011 [28]	Decision authority	Two outcomes, see column to the right	Standardized regression coefficient **Sleep disturbance**: - 0.01, n.s **Awakening problems**: − 0.04, $p < 0.05$
Jansson and Linton, 2006 [29]	Influence over decisions	Insomnia	Depending on insomnia at baseline OR (95% CI) no: ns yes: 1.30 (1.05; 1.62)
Takahashi et al., 2012 [30]	Work time and job control	Two outcomes, see column to the right	Depending on type of control, correlation **Insomnia**: −0.09, $p < 0.001$, to −0.10, $p < 0.001$ **Incomplete recovery**: −0.15, $p < 0.001$, to −0.15, $p < 0.001$
Job strain			
de Lange et al., 2009 [25]	Job strain	Sleep quality	High strain group, mean (SD): 1.13 (0.11) Low strain group, mean (SD): 0.25 (0.09)
Edmé et al., 2011 [26]	Job strain	Sleep problems	OR (95% CI) f: 0.68 (0.32; 1.46), m: 1.89 (1.16; 3.06)
Elovainio et al., 2009 [32]	Job strain	Sleeping problems	Job strain, mean (95% CI): 11.8 (11.3; 12.3) No job strain, mean (95% CI): 11.3 (10.9; 11.6) p for difference: 0.039
Ota et al., 2009 [33]	High strain	Insomnia	Depending on insomnia at baseline OR (95% CI) yes: 1.27 (0.75; 2.16), no: 1.53 (0.97; 2.43)
Reward			
Åkerstedt et al., 2012 [24]	Work preoccupation	Disturbed sleep	Increased to consistently high, OR (95% CI) 1.89 (1.58; 2.26) to 3.40 (2.33; 4.95)
Edmé et al., 2011 [26]	Effort-reward imbalance, low reward	Sleep problems	OR (95% CI) Imbalance: f: 0.79 (0.37; 1.69), m: 2.20 (1.43; 3.38) Low reward: f: 0.65 (0.33; 1.30), m: 1.70 (1.12; 2.57)
Eriksen et al., 2008 [27]	Rewards for well-done work	Poor sleep	Rather low to very high reward, OR (95% CI) 0.85 (0.67; 1.08) to 0.75 (0.41; 1.36)
Ota et al., 2009 [33]	Effort-reward imbalance	Insomnia	Depending on insomnia at baseline OR (95% CI) yes: 1.28 (0.6; 2.67), no: 2.18 (1.08; 4.40)
Rugulies et al., 2009 [36]	Effort-reward imbalance	Sleep disturbance	Low to high imbalance, OR (95% CI) f: 1.31 (0.86; 1.99) to 1.07 (0.66; 1.73) m: 1.43 (0.80; 2.55) to 2.02 (1.15; 3.55)
Social support			
Edmé et al., 2011 [26]	Social support	Sleep problems	OR (95% CI) f: 0.97 (0.49; 1.94), m: 1.13 (0.74; 1.73)
Eriksen et al., 2008 [27]	Support from immediate superior	Poor sleep	Depending on level of support, (level 5 to 2), OR (95% CI) 0.67 (0.46; 1.00) to 0.90 (0.68; 1.20)
Hanson et al., 2011 [28]	Support	Two outcomes, see column to the right	Standardized regression coefficient **Sleep disturbance**: −0.25, $p < 0.001$ **Awakening problems**: −0.04, $p < 0.05$
Jansson and Linton, 2006 [29]	Peer and leader support	Insomnia	Depending on insomnia (ins.) at baseline, OR (95% CI): Leader: initial ins.: ns, no initial ins.: 0.69 (0.51; 0.94) Peer: initial ins.: ns no initial ins.: ns
Linton, 2004 [34]	Social support at work	Sleep problems	OR (95% CI): 1.64 (1.06; 2.54)
Ota et al., 2009 [33]	Low social support	Insomnia	Depending on insomnia at baseline, OR (95% CI) no: 0.92 (0.61; 1.37), yes: 1.70 (1.04; 2.72)

(*continued on next page*)

Table 2 (*continued*)

Author, reference number	Exposure	Outcome	Association
Takahashi et al., 2012 [30]	Social support at work	Two outcomes, see column to the right	**Insomnia**, correlation: −0.11, $p < 0.001$ **Incomplete recovery**, correlation: −0.10, $p < 0.001$
Justice			
Elovainio et al., 2009 [32]	Organizational justice	Four outcomes, see column to the right	Regression coefficients (beta) **Sleeping problems**: f: −0.10, $p < 0.001$, m: −0.11, $p < 0.001$ **Sleep onset**: f: −0.005, ns, m: −0.07, ns **Sleep maintenance**: f: −0.09, $p < 0.001$, m: −0.08, $p < 0.001$ **Non refreshing sleep**: f: −0.11, $p < 0.001$, m: −0.12, $p < 0.001$
Eriksen et al., 2008 [27]	Fairness of immediate superior	Poor sleep	Depending on level of fairness (level 2–5), OR (95% CI) 1.02 (0.74; 1.41) to 1.25 (0.90; 1.73)
Greenberg, 2006 [35]	Under-payment inequity	Insomnia	Underpaid nurses experienced greater insomnia than those with unchanged pay. Anova: $F(2, 1398) = 1.317$, $p < 0.01$
Bullying, violence and social exclusion			
Eriksen et al., 2008 [27]	Bullying and violence at work	Poor sleep	Bullying, OR (95% CI): 0.65 (0.43; 0.98) Violence, rather seldom to rather often, OR (95% CI) 0.87 (0.68; 1.13) to 1.77 (1.27; 2.46)
Lallukka et al., 2011 [37]	Bullying	Sleep problems	Reported bullying, OR (95% CI) f: 1.69 (1.30; 2.20), m: 3.17 (1.85; 5.43) Observed bullying, sometimes to often, OR (95% CI) f: 1.13 (0.99; 1.30) to 2.00 (1.61; 2.48) m:1.15 (0.85; 1.56) to 2.04 (1.23; 3.39)
Pereira et al., 2012 [38]	Social exclusion	Four outcomes, see column to the right	Correlation coefficient (SE) **Sleep fragmentation**: 0.23 (0.12), $p < 0.05$ **Sleep onset latency**: 0.30 (2.41), ns **Sleep efficiency**: −0.31 (1.52), ns **Self-reported sleep quality**: 0.04 (0.15), ns
Weekly working hours			
Åkerstedt et al., 2001 [43]	Reduced working time	Four outcomes, see column to the right	Experimental group (before − after working time reduction) vs control group, Anova F-value **Insomnia complaints**: between groups 1.1, over time 15.4 **Sleep quality**: between groups 1.8, over time 0.7 **Difficulty waking**: between groups 0.2, over time 1.7 **Refreshing sleep**: between groups 1.1, over time 18.5
Eriksen et al., 2008 [27]	>36 working-hours per week	Poor sleep	OR (95% CI): 1.17 (0.90; 1.52)
Virtanen et al., 2009 [39] (high)	Long working weeks	Four outcomes, see column to the right	41–55 to 55 + h/wk at 1st measurement, OR (95% CI) **Difficult falling asleep**: 1.58 (0.88; 2.82) to 3.68 (1.58; 8.58) **Frequent waking**: 0.94 (0.69; 1.27) to 0.86 (0.50; 1.33) **Early waking**: 1.04 (0.73; 1.46) to 1.58 (0.91; 2.73) **Non-refreshing sleep**: 1.14 (0.76; 1.72) to 1.98 (1.04; 3.77) 41–55 to >55 h/wk at 2nd measurement, OR (95% CI) **Difficult falling asleep**: 1.63 (0.88; 3.00) to 6.66 (2.64; 16.83) **Frequent waking**: 1.08 (0.78; 1.49) to 1.17 (0.60; 2.25) **Early waking**: 1.26 (0.87; 1.82) to 2.23 (1.16; 4.31) **Non-refreshing sleep**: 1.48 (0.96; 2.28) to 1.85 (0.79; 4.39)
Shift work			
Åkerstedt et al., 2010 [42]	Shift work	Four outcomes, see column to the right	Entry shift, new cases, OR (95% CI) **Difficult falling asleep**: 1.73 (1.14; 2.63) **Difficult waking**: 0.92 (0.56; 1.51), **Repetitive waking**: 0.98 (0.80; 1.20) **Not rested**: 1.28 (0.85; 1.94) Working shift, new cases, OR (95% CI) **Difficult falling asleep**: 1.08 80.88; 1.32) **Difficult waking**: 1.12 80.89; 1.42)) **Repetitive waking**: 0.98 (0.80; 1.20 **Not rested**: 1.14 (0.93, 1.39) Exit shift, loss of cases, OR (95% CI) **Difficult falling asleep**: 2.82 (1.78; 4.48) **Difficult waking**: 1.40 (0.88; 2.23) **Repetitive waking**: 1.77 (1.13; 2.78) **Not rested**: 0.67 (0.37; 1.21)
Amendola et al., 2011 [40] (high)	Shift length	Two outcomes, see column to the right	Associated effect sizes, pre-test as covariate, Ancova F (df) **Average sleep quality**; 0.865 (2.147), $p = 0.423$ **Apnea**: 0.208 (2.224), $p = 0.812$
Karlson et al., 2009 [41] (high)	Change of shift rotation	Awakening problems and sleep disturbance	Before vs after shift change, mean difference between groups divided by average standard deviation Shift workers: 0.33 to 0.36, $p < 0.001$ Daytime workers: 0.01 $p = 0.583$ to 0.06 $p = 0.942$ Interaction time × group: $p = 0.001$ to 0.006
Linton, 2004 [34]	Shift work, irregular hours	Sleep problems	OR (95% CI) **Shift work**: 1.21 (0.53; 2.72) **Irregular working hours**: 1.02 (0.60; 1.72)

Table 2 (*continued*)

Author, reference number	Exposure	Outcome	Association
Niedhammer et al., 1994 [44]	Shift work	Sleep quality	Transfer from shift work to daytime work, 1st and 2nd measurement, OR (95% CI) 0.49 (0.17; 1.44) and 3.01 (1.43; 6.34)
Rosa et al., 1996 [45]	Work schedule change	Two outcomes, see column to the right	Interaction of test phase with shift, Anova F-values **Sleep quality**: exp: 3.42, $p = 0.02$, control: <1, ns **Refreshing sleep**: exp: 10.92, $p = 0.001$, control: 1.05, ns
Night work			
Åkerstedt et al., 2010 [42]	Night work	Four outcomes, see column to the right	Entry night work, new cases, OR (95% CI) **Difficult falling asleep**: 0.82 (0.33; 2.00) **Difficult waking**: 2.30 (1.00; 5.28) **Repetitive waking**: 0.38 80.13, 1.11) **Not rested**: 0.95 (0.41; 2.21) Working night, new cases, OR (95% CI) **Difficult falling asleep**: 1.08 (0.72; 1.62) **Difficult waking**: 1.14 (0.72; 1.81) **Repetitive waking**: 1.30 80.87; 1.94) **Not rested**: 1.04 (0.70; 1.56) Exit night work, loss of cases, OR (95% CI) **Difficult falling asleep**: 1.91 (0.97; 3.74) **Difficult waking**: 1.21 (0.65; 2.22) **Repetitive waking**: 1.44 (0.75; 2.76) **Not rested**: 0.80 (0.41; 1.59)
Eriksen et al., 2008 [27]	Night shift work	Poor sleep	Sometimes to very often, OR (95% CI) 0.92 (0.75; 1.13) to 0.95 (0.72; 1.25)
Linton, 2004 [34]	Night work	Sleep problems	OR (95% CI): 1.34 (0.55; 3.29)
Chemical exposure			
Heiskel et al., 2002 [46]	Fuel, paint and solvents	Obstructive sleep apnea	Low to high exposure level, general population, OR (95% CI) **Gasoline**: 1.1 (0.6; 1.8) to 0.6 (0.3; 1.2) **Diesel fuel**: 0.8 (0.4; 1.5) to 1.0 (0.5; 2.2) **Paints**: 0.8 (0.5; 1.2) to 1.0 (0.4; 2.2) **Solvents**: 1.2 (0.8; 1.9) to 0.8 (0.4; 1.6) Low to high exposure level, laboratory group, OR (95% CI) **Gasoline**: 0.7 (0.4; 1.4)) to 0.2 (0.1; 0.5) **Diesel fuel**: 1.0 (0.4; 2.5) to 0.5 (0.2; 1.0) **Paints**: 0.6 (0.3; 1.1) to 0.5 (0.2; 1.5) **Solvents**: 1.0 (0.5; 1.9) to 0.8 (0.3; 1.8)
Postuma et al., 2012 [47]	Pesticids, herbicids and insecticids	REM sleep behavior disorder	Occupational use, OR (95% CI) **Pesticid**: 2.23 (1.24; 4.01) **Herbicid**: 2.54 (1.05; 6.16) **Insecticid**: 3.67 (1.42; 9.30)
Job insecurity			
Burgard and Ailshire, 2009 [31]	Job insecurity	Sleep quality	Job insecurity and change in job insecurity, OR (95% CI) 1.09 (0.895; 1.322) and 1.04 80.873, 1.228)
Manual handling and physical endurance			
Eriksen et al., 2008 [27]	Manual handling and physical endurance	Poor sleep	Handling heavy objects, 1–4 to 10 + times/shift, OR (95% CI) 1.06 (0.85; 1.32) to 1.02 (0.65; 1.61) Physical endurance, seldom to very often, OR (95% CI) 0.98 (0.61; 1.57) to 0.81 (0.51; 1.30)

Abbreviations: CI: confidence interval, exp: exposed, f: females, m: males, ns: not significant, OR: odds ratio. Three studies were assessed as high quality (indicated with "high" in the left column). The other 22 studies were assessed as medium quality in the expert evaluation.
Odds ratios are significant at 5% level when the 95% confidence interval is strictly below or above 1.00.

Six studies examined the effects of work demands on future sleep disturbances [24–29] and two focused on the association between control and sleep disturbances [30,31]. The section "demands" in Table 2 summarizes the results. Four of the six studies reported a statistically significant association between higher levels of work demands and sleep disturbances and one showed a significant association for men, but not for women. In Fig. 2 the relationship between higher demands and sleep disturbances is illustrated in a forest plot. The summary odds ratio was 1.38 (95% CI = 1.28 to 1.49, fixed effects model; OR = 1.48, 95% CI = 1.28 to 1.72, random effects model).

The effects of control over work are given in the section labeled "control" in Table 2. Several, but not all, studies report an association between higher levels of control at work and *lower* levels of sleep disturbances. However, the size of the association varies between studies and was generally small. Six of the eight studies reported data that could be included in a meta-analysis of higher levels of control, resulting in a summary odds ratio of 0.90 (95% CI = 0.84 to 0.98, fixed effects model; OR = 0.93, 95% CI 0.78 to 1.12, random effects model). Meta-analysis of lower levels of control showed the opposite pattern of association, with a summary odds ratio just above 1.

Job strain was investigated in four articles [25,26,32,33] in Table 2. There was an association between reporting job strain and future reports of sleep disturbances, and a meta-analysis of comparable data from all four studies showed a summary odds ratio of 1.32 (95% CI = 1.19 to 1.47, fixed effects model; OR = 1.35, 95% CI = 1.17 to 1.56 random effects model).

Seven articles investigated social support at work and future sleep disturbances [26–30,33,34] in Table 2. Several studies indicated an association between *higher levels* of social support and a *lower* frequency of sleep disturbances. Data from four studies was entered into a meta-analysis as shown in Fig. 3. The summary odds ratio is 0.77 (95% CI = 0.71 to 0.85, fixed effects model; OR = 0.74,

Table 3
A summary of the evidence for variables with sufficient data to draw a conclusion on the relationship between work environment factors and future sleep disturbances.

Work-related factor	Participants	Studies	Scientific evidence
Association between occupational environment and less disturbed sleep			
Social support at work	11,724	4	⊕⊕❍❍
Organisational justice	10,447	3	⊕⊕❍❍
Control	18,192	8	⊕⊕❍❍
Stop working shift	3850	2	⊕⊕❍❍
Association between occupational environment and sleep disturbance			
High demands	14,709	6	⊕⊕⊕❍
Decreased control	4,178	2	⊕⊕❍❍
Job strain	8,521	4	⊕⊕❍❍
Job strain − men	4,560	2	⊕⊕❍❍
Effort-reward imbalance	4,527	3	⊕⊕❍❍
Effort-reward imbalance − men	1,994	2	⊕⊕❍❍
Low reward	6,667	2	⊕⊕❍❍
Bullying, including social exclusion	13,821	3	⊕⊕❍❍
Shift work	4666	3	⊕⊕❍❍
The scientific evidence is in-sufficient (⊕❍❍❍) to determine if there is a correlation between the following occupational factors and sleep disturbance			
Demands - decreasing, Demands − increasing, Control − increasing, Job strain − women, Job strain − increasing, Job strain − decreasing, Effort-reward imbalance − women, Low reward − men, Low reward − women, Work preoccupation, Low social support at work, Violence or threats at the work place, Job insecurity			
Reduced work time, Long weekly working hours, Entering shift work, Length of shift, Time for changing shift, Rotational pattern of shift, Night work			
Manual handling, Physical endurance, Exposure to solvents, Exposure to pesticides			

⊕⊕⊕❍- There is scientific evidence for an association between exposure and outcome. The result is based on studies of high or moderate quality. The quality of evidence has been upgraded due to consistency of the data.
⊕⊕❍❍- There is scientific evidence for an association between exposure and outcome. The result is based on studies of high or moderate quality.
⊕❍❍❍- It is not possible to determine if there is an association between exposure and outcome. The motivation is that one or several conditions apply: 1) no study fulfilled the inclusion criteria, 2) none of the studies fulfilling the inclusion criteria were relevant to the hypothesis tested in the present review, 3) all relevant studies were of low quality or 4) studies were of high or moderate quality − but one or several limitations applied, e.g. inconsistency of data between studies.

95% CI = 0.61 to 0.90, random effects model) demonstrating an association between higher levels of support and a lower frequency of future sleep disturbances.

The results from studies investigating the effects of *lower levels* of social support, i.e., the opposite direction from above, were varied. Comparable data from the three studies investigating the relationship with sleep complaints [26,33,34] were entered into a meta-analysis, resulting in a summary odds ratio of 1.15 (95% CI = 0.92 to 1.45, fixed effects model; OR = 1.15, 95% CI = 0.88 to 1.50 random effects model).

The effects of organizational injustice at the workplace were considered in three studies (Table 2). Two of the reports [27,32] investigated self-reported injustice at the workplace while one study investigated the effects of reducing wages [35]. Four comparisons from the three studies were entered into a meta-analysis giving a summary odds ratio of 0.73 (95% CI = 0.66 to 0.79, fixed effects model; OR = 0.80, 95% CI = 0.64 to 1.00, random effects model). Combining the data from the meta-analysis and the additional data in the three studies indicates that injustice was related to future reports of sleep disturbances.

There were four studies that considered inadequate reward at the workplace as seen in Table 2. Three of the reports [26,33,36] investigated effort-reward imbalance, one investigated the effects of rewards [27] and one study investigated work pre-occupation [24]. Studies on effort-reward imbalance were entered into a meta-analysis giving a summary odds ratio of 1.51 (95% CI = 1.18 to 1.94, fixed effects model; OR = 1.44, 95% CI = 0.98 to 2.11, random effects model). Taking all of the relevant data into account, the results indicate that effort-reward imbalance was likely related to future reports of sleep disturbances.

The effects of various forms of bullying at the workplace on sleep disturbances were scrutinized in three papers [27,37,38] (Table 2). Lallukka et al. found that self-reported as well as actually observed bullying was associated to future sleep disturbances for both men and women. Pereira et al. reported mixed results with some analyses being significant and some not, while Eriksen et al. reported a weak inverse relationship. Four comparisons from the studies were entered into a meta-analysis and the summary odds ratio was 1.44 (95% CI = 1.18 to 1.76, fixed effects model; OR = 1.42, 95% CI = 0.75 to 2.68, random effects model). The overall picture indicates that bullying is likely related to future sleep disturbances.

Work schedules

Both the number of hours worked and the particulars of when the work occurs have been suspected to impact on future sleep disturbances. Overall, we found nine studies investigating the possible effects of work schedules on future sleep disturbances [27,34,39–45].

The length of the working week was investigated in three studies [27,39,43] in Table 2. Two of the studies investigated the effects of long working hours while the third focused on a reduction from 39 to 30 h per week. In the study by Eriksen et al., working longer than 36 h per week was not related to poor sleep. Similarly, in the Virtanen et al. report working long hours was not related to sleep when the number of hours was moderate (41–55 h). However, when work hours exceeded 55 per wk there was an association with several of the investigated types of sleep disturbances. Decreasing work hours from 39 to 30 h showed mixed results with an association to self-reported sleep quality but not to insomnia. Because of the vast differences in the designs and reporting of the data, no meta-analysis could be performed and it was not possible to determine if there is any association between weekly work hours and future sleep disturbances.

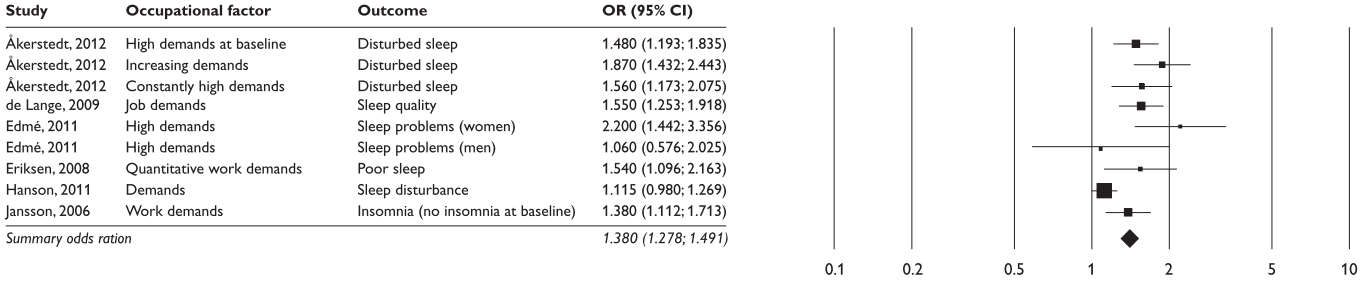

Fig. 2. Forest plot illustrating the association between work demands and sleep disturbances. All data have been transformed into odds ratios.

Study	Occupational factor	Outcome	OR (95% CI)
Eriksen, 2008	Support from superior	Poor sleep	0.670 (0.454; 0.988)
Hanson, 2011	Support	Sleep disturbance	0.897 (0.788; 1.020)
Jansson, 2006	Leader support	Insomnia (no insomnia at baseline)	0.690 (0.508; 0.937)
Takahashi, 2012	Social support at work	Insomnia	0.669 (0.578; 0.775)
Summary odds ration			*0.773 (0.707; 0.846)*

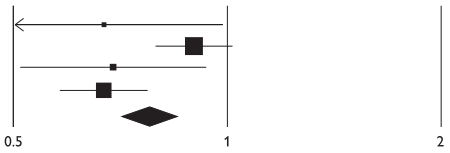

Fig. 3. Forest plot illustrating the association between high levels of social support and low frequency of sleep disturbances. All data have been transformed into odds ratios.

Shift work and irregular working hours relative to sleep disturbances were explored in six studies [34,40–42,44,45] (Table 2). The studies approached work schedules somewhat differently as three looked at working steady shifts [34,42,44], three investigated changes in shift schedules [40,41,45], and two examined starting or quitting shift work [42,44]. The meta-analysis of the three comparable studies [34,42,44] investigating steady shift work gave a summary odds ratio of 1.16 (95% CI = 0.97 to 1.38, fixed effects model; OR = 1.17,95% CI = 0.96 to 1.43 random effects model).

A second way to explore work schedules is to investigate entering and exiting shift work, but the studies produced mixed results. Exiting shift work was linked to fewer cases of having difficulty falling asleep and fewer cases of repetitive awakening in the study by Åkerstedt et al. [42] as well as improved sleep quality at the second measurement in the paper by Niedhammer et al. [44]. Studies investigating entering shift work showed mixed results. In addition, the intervention studies [40,41,45] analyzed quite different aspects of shift work which precludes comparison between them and the cohort studies. A consideration of all of the results indicates that shift work is likely related to future sleep disturbance.

A third aspect of work schedules is night work. Three studies were identified [27,34,42], but none of them reported any statistically significant association (Table 2).

The physical work environment

Various aspects of the physical work environment were considered. Two studies examined associations with solvents [46] and pesticides and herbicides [47], as seen in the section “chemical exposure” in Table 2. Heiskel et al. [46] found no association between solvents exposure and sleep apnea, whereas Postuma et al. [47] reported that working with pesticides was related to REM sleep disorders. Because only one study of each type of exposure fulfilled our criteria it was not possible to determine if there was any association between these exposures and future sleep disturbances. The same was true for physical exertion, since only one study fulfilled our criteria, see the section “manual handling and physical endurance” in Table 2. With regard to noise, vibration, radiation and temperature, as well as contagions, we did not find any single study that fulfilled the inclusion, relevance and quality criteria.

Discussion

This comprehensive review shows that the work environment likely impacts on how workers sleep. As shown in Table 3, there is evidence that four workplace factors are related to fewer future sleep disturbances and nine are related to the development of future sleep disturbances. In order to be able to draw such conclusions, we systematically reviewed the literature including only prospective studies, rated as fulfilling a strict scientific quality threshold, and the strength of the evidence has also been graded according to standardized procedures. We included the results from all of the studies in drawing conclusions. Of the 24 studies meeting our inclusion criteria most dealt with psychosocial factors at work and the effects of work schedules. Our results point to the notable role work factors likely have on sleep and sleep disturbances and they provide a guide for future research as well as possible interventions to improve workers' sleep. We welcome future research in this area to further verify the results and encourage scientists to explore other exposure variables and to strengthen the methodology.

We found evidence that psychosocial factors at work impact on future sleep disturbances. While social support at work, organizational justice, and control over work were associated with fewer sleep disturbances, the inverse was also found in that decreased control over work and social problems e.g., bullying and exclusion were associated with increased levels of sleep disturbances. Taken together this provides scientific evidence that psychosocial factors impact on sleep. In addition, factors included in theoretical conceptions e.g., the effort-reward and demand-control models have received support since imbalances in these factors were related to sleep disturbances.

Given the large variation in the studies, the magnitude of the effects was difficult to establish. First, not all studies could be included in the meta-analyses due to the way the data were reported. The studies also employed different methodologies and measures. The size of the effect may also be related to factors such as which outcome is in focus as one study reports that subjective reports of sleep disturbances are more strongly related than objective measures [48]. Judging the size of the effect also entails knowing the time line for a given variable's impact on sleep. Some variables (like injustice) might impact very quickly while others might accumulate over time. Therefore, it is difficult to determine the size of the effects until we have better knowledge about the underlying mechanisms. Taken as a whole, we conclude that there is scientific evidence to support these associations, but we were unable to determine reliably their magnitude.

Work schedules also demonstrated a relationship with future sleep disturbances. As Table 3 illustrates, terminating shift work was associated with fewer future sleep disturbances. Likewise, working shifts was associated with future sleep disturbances. Together this provides evidence that working shifts impacts on sleep. However, because of the way the data were reported, we could not draw any conclusions about the size of the effects of shift work on sleep. There were too few studies concerning other aspects of work schedules to draw any conclusions.

While the physical work environment is believed to be of importance for sleep, we located only two studies that fulfilled our inclusion criteria. Because they dealt with different types of exposure, there was insufficient evidence to draw conclusions. However, future research should rectify this lack of data. For example, physical activity at work might promote good sleep since some studies indicate that higher daytime physical activity is related to less insomnia [49]. Moreover, modern work environments include a range of factors that might potentially result in sleep disturbances such as working with high technological devices or exposure to various agents. Finally, the physical work environment might interact with psychosocial factors.

We have identified relationships between certain factors in the work environment and future sleep disturbances, but several methodological concerns should be kept in mind when interpreting the results of our review. Indeed, our conclusions are influenced by the number of studies, the variables included and their methodology. While we are acutely aware that conducting high quality studies in this area is very challenging, several issues nevertheless need to be tackled if the field is to move forward. For example, to date investigations typically employ self-reports, rather than objective measures, for assessing both the exposure and the outcome introducing possible bias and circularity. Moreover, outcome was sometimes assessed with a single item making it difficult to capture the complexity of sleep and limiting validity. In addition, publication bias is a typical problem for systematic reviews, but this was difficult to assess. Moreover, even though systematic and extensive, our search strategy may also have influenced the results for example by not including all possible search words e.g., "leadership". Although many studies attempted to control for confounders, the selection of participants and the measurement of possible confounders often fell short of the mark. As an illustration, the healthy worker effect needs to be taken into account. For example a worker suffering sleep difficulties who works shifts may change work to a job without shifts and therefore the effects of shift work on sleep might be underestimated. Further, other variables such as personality factors that might result in negative evaluations of both the environment and sleep should be considered in future research. The follow-up period is yet another vital factor in determining the effects of the work environment on sleep. However, as discussed above, it is not clear how long participants should be followed since the duration and intensity of exposure needed to significantly impact on sleep is unknown. In general, follow-up periods in future studies should be long enough to avoid an underestimation of the effects of the occupational exposure. Furthermore, the investigations we included assumed that the direction of the effect is the work environment impacting on sleep. Still, the opposite might be true (i.e., that sleep disturbances might result in experiencing the work environment negatively) and reverse relationships also need to be studied more thoroughly. Although we have selected prospective and intervention studies given their methodological advantages in comparison to cross-sectional investigations, the results reflect a relationship that is not necessarily "cause and effect". Not only are reverse relationships possible, but third factors might be related to both the work environment and sleep. For example, it is possible that a biological susceptibility or a psychological factor e.g., anxiety or personality might play a causal role. Above all, we do not yet know the actual mechanism by which the work environment factors impact on sleep. Theoretical and experimental studies could advance our understanding. Taken together, future research needs to focus on better methodology and elucidate the mechanisms involved.

Our review has several implications since sleep disturbances have numerous implications for health and work. Clinicians should assess work factors in patients of working age and consider such factors in treatment programs. Workplaces might also be advised by the results when designing improvements in the work environment. Thus, workplaces can use this information to prevent future sleep problems. Scientifically, the results of this review suggest that psychosocial work factors as well as the scheduling of work is implicated in the development of sleep disturbances. The results support the effort-reward and demand-control models although new, more powerful models need to be developed. In the clinic, practitioners should consider work place factors when working with people with sleep disturbances. By employing better methodology such as prospective or experimental designs, future research may open important doors for understanding the development of sleep disturbances in workers.

Practice points

Given the relationship between the work environment and sleep disturbances, it may be helpful to:

Assess work environmental factors for employed patients complaining of sleep disturbances
Consider work environment issues when treating workers with sleep complaints
Utilize this knowledge when employers seek ways of reducing or preventing disturbances e.g., by improving the psychosocial work environment and work scheduling.

Research Agenda

Future research should focus on improving methodology so that we can:

Determine the nature of the relationship between work and sleep including the size of the effect and if disturbed sleep influences the perception of the work environment
Identify the mechanisms by which the work environment influences sleep
Develop better theoretical models that promote an in-depth understanding of the relation between work and sleep
Study how work environment interventions might reduce sleep disturbances

Conflicts of interest

This review has been funded by the Swedish Council on Health Technology Assessment. The authors have no conflicts of interest.

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